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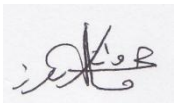

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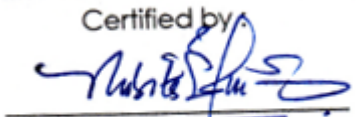

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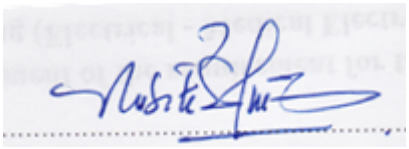
Signature : 

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BLUETOOTH WIRELESS HEART RATE TELEMONITORING

WAN FAIRUZ JAMILAH BT W MOHD RIDZWAN

A project report submitted in partial fulfilment of the requirement for the award of the Degree of Bachelor of Engineering (Electrical - Medical Electronics)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MAY 2011

I declare that this project report entitled "*Bluetooth Wireless Heart Rate Telemonitoring*" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

In the era where technology kept changing our course of life, improvement in medical field have become most needed and developed as people concern about their health above all. There are various researches done all over the world to monitor health condition in the easiest way. As cable becoming a burden to the user for limited mobility, researchers kept finding methods to replace the usage of cables in connecting the electronic devices. This project is also one of the research done in order to make health monitoring is easier without using cables. This project has proposed a method of wireless health monitoring using Bluetooth technology. There are four parts in this project that is sensor development, amplifier development, data processing and wireless transmission via Bluetooth. Sensor and amplifier was developed to obtain amplified heart rate signal. However due to inconsistency of output from both sensor and amplifier, the heart rate was obtained using ECG simulator and amplified using biomedical amplifier. Then, input was processed and wirelessly transmitted to laptop using microcontroller and Bluetooth module. The output signal was displayed on laptop screen.

ABSTRAK

Dalam era dimana teknologi semakin mengubah gaya kehidupan kita, kemajuan dalam bidang perubatan adalah yang paling diperlukan kerana manusia mementingkan kesihatan mereka lebih dari yang lain. Pelbagai kajian telah dilaksanakan di seluruh dunia untuk meninjau tahap kesihatan dengan cara yang paling mudah. Penggunaan kabel semakin membebankan pengguna kerana menyebabkan pergerakan semakin terhad. Oleh itu para pengkaji sering mencari kaedah untuk menggantikan penggunaan kabel dalan menghubungkan peralatan elektronik. Projek ini juga adalah salah satu daripada kajian yang telah dilaksanakan untuk memudahkan peninjauan tahap kesihatan diri tanpa menggunakan kabel. Projek ini telah mencadangkan kaedah peninjauan tahap kesihatan melalui penggunaan teknologi Bluetooth. Projek ini terdiri daripada empat bahagian iaitu sensor, penguat, pemprosesan data dan juga penghantaran data melalui Bluetooth. Sensor dan penguat telah di hasilkan untuk mendapatkan kadar denyutan jantung yang diperbesarkan. Namun begitu, disebabkan oleh sensor dan penguat yang dihasilkan tidak stabil, kadar denyutan jantung telah diambil dari ECG Simulator dan signal diperbesarkan menggunalan penguat bioperubatan. Kemudian, input tersebut diproses dan dihantar ke laptop tanpa menggunakan wayar dengan menggunakan microcontroller dan Bluetooth.

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LIST OF ABBREVIATIONS

ALU	–	Arithmetic Logic Unit
ECG	–	Electrocardiogram
I/O	–	Input / Output
IC	–	Integrated Circuit
ISM	–	Industry Scientific and Medical
LED	–	Light Emitting Diode
PCB	–	Printed Circuit Board
PDA	–	Personal Digital Assistant
PPG	–	Photoplethysmograph
QoS	–	Quality of Service
RF	–	Radio Frequency
SIG	–	Special Interest Group
UART	–	Universal Asynchronous Receiver Transmitter

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CHAPTER 1

INTRODUCTION

1.1 Research Background

1.1.1 Heartbeat

Heart is one of the five vital organs. It can be found in all animals with a circulatory system including all vertebras. Human heart basically a hollow, cone shaped, 10cm in length and about the size of subject fist. It lies in the thoracic cage, in the middle of chest area, just left of the center. Heart is responsible for pumping blood throughout the blood vessels by repeated rhythmic contractions while rib cage is responsible for heart protection [1].

Deoxygenated blood enters heart through superior vena cava and the heart will pump the blood to lungs through pulmonary trunk. Exhalation process in lungs removes carbon dioxide from blood and inhalation process absorb oxygen into blood. Oxygenated blood returns from lung enter heart through pulmonary veins and will be pumped throughout the body through aorta.

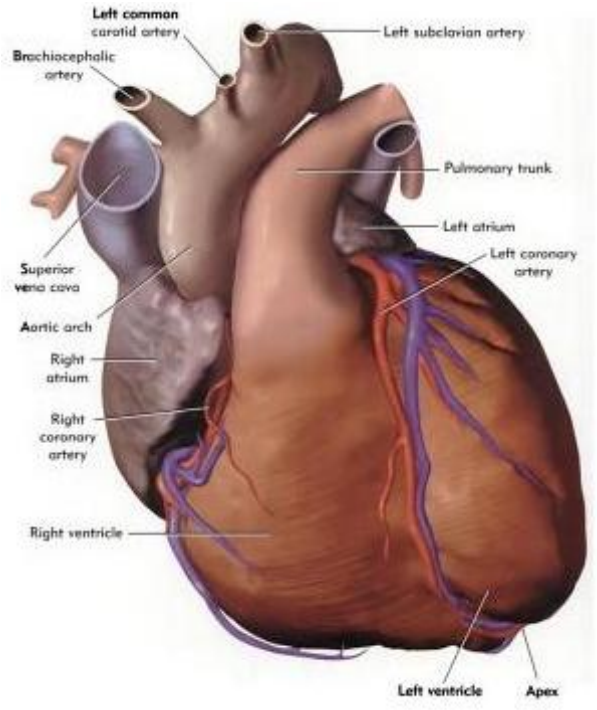

Figure 1.1 Human heart (Adapted from [1])

Whether a person is awake or asleep, the heart never fails to pump. Heart contracts and relaxes in a rhythmic cycle. When it contracts, it pumps blood. When it relaxes, its chambers filled with blood. One complete sequence of pumping and filling is called cardiac cycle. The volume of blood per minute that the left ventricle pumps into the systemic circuit is called cardiac output. Heart rate and stroke volume will determine cardiac output. Heart rate is the number of heart beat per unit of time usually in unit of beat per minute (BPM). It is measured from the artery pulse in the body (chest, wrist fingertips, etc). Heart rate can be measured by using heart rate monitoring system. Stroke volume is the amount of blood pumped by left ventricle in each contraction. In human heart, average stroke volume is about 75 mL. At rest, a person heart beats about 70 beats per minute has cardiac output of 5.25 L/min. This is equivalent to the total volume of blood in human body. During heavy exercise, cardiac output will increase [2].

1.1.2 Electrocardiogram

When the heart muscle cells contract to make heart pumps the blood, it generates an action potential which spread currents throughout the body. In various parts of the body, different electrical potential were produced and this difference can be recorded using surface electrodes attached to the skin. These waveforms are called electrocardiogram (ECG) [3].

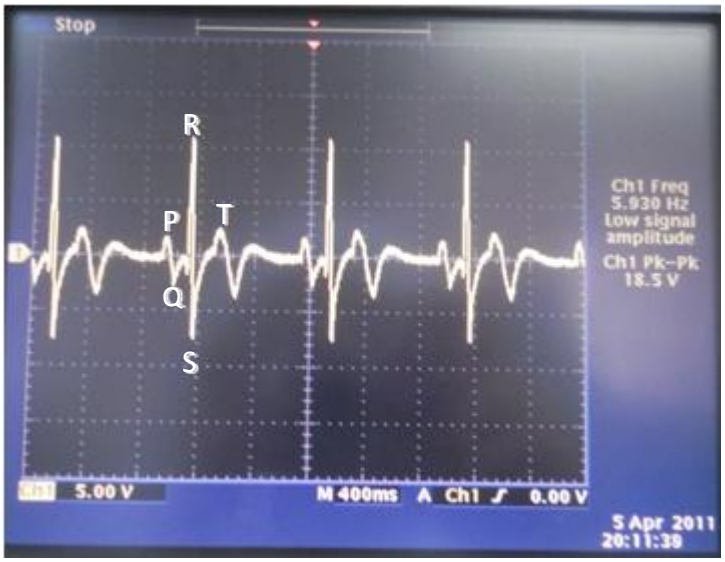

Figure 1.2 Typical ECG waveform

Typically, ECG signal is measured from left arm to right arm and the waveform measured usually as shown in Figure 1.2 ECG signal consist of P wave, QRS complex, and a T wave which is normally visible in every ECG signal measured. P wave occur during normal atrial depolarization when the main electrical vector is directed from the SA node towards the AV node and spreads from right atrium to left atrium. It usually occurs within 80 ms. PQ interval is measured from beginning of P wave to the beginning of QRS complex. This interval shows the time required for electrical impulse to travel to sinus node through AV node and entering ventricles. The duration is between 120 to 200 ms. QRS complex shows rapid depolarization of right and left ventricles. It usually occurs between 80 to 120 ms. Lastly, T wave represent the repolarization, in other word a recovery phase of ventricles.

1.1.3 Photoplethysmograph

Photoplethysmograph (PPG) is a technique based on relative transparency of human skin for red or near infrared light and on the diffusing effect of red blood cells which reduces these wavelength retrodiffusions. Therefore PPG technique can be used to measure any type of blood volume variation at the tested site [4].

When the source of light placed against the skin, the retrodiffused light will be detected by photoelectric cell located in the same place. There are two types of signal that can be used; first, the retrodiffused light systolic-diastolic variation and second, through systolic-diastolic damping, the variation of the retrodiffused light baseline. The first type of signal deals with sphygmic or arterial PPG while the second type deals with volume or venous PPG.

The retrodiffused light depends on the variation of quantity of red blood cells within the skin. The larger the volume of red blood cells, the lower the retrodiffused light. Figure 1.3 shows an example of normal PPG obtained by using pulse oximeter.

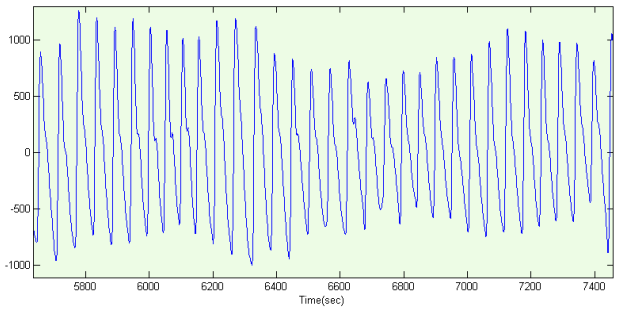

Figure 1.3 PPG obtained using pulse oximeter (Adapted from [5])

1.1.4 Instrumentation Amplifier

Amplifier is an electronic circuit that has the capability to amplify power, voltage of current. Amplifiers are needed in a situation where the input is very small. In order to have a better analysis, there is a need to amplify the signal so that the output will be higher thus making the signal analysis easier. However there are also

possibilities that amplifier circuit will amplify not only required signal but also amplify the noise. Noise can be defined as unwanted signal. Therefore, in order to make the signal analysis, the noise must be removed. One of the methods to remove noise and amplify wanted signal is by using bioelectric amplifiers. Bioelectric amplifiers are used to process bipotential signals. The bioelectric signal is unique to biomedical systems. It is generated by nerve cells and muscle cells. Its source is the membrane potential, which under certain conditions may be excited to generate an action potential [6].

The gain of bioelectric amplifiers can either be low, medium or high depending on their application. The gain factor of low gain bioelectric amplifier usually is in the range of unity (×1) to ×10. The uses of unity gain (×1) amplifiers are mostly for isolation, buffering and possibly impedance transformation between signal sources and read out device [3]. For medium gain bioelectric amplifiers, the gain factors are usually in range of ×10 to ×1000. They are mostly used for ECG waveform recordings, muscle potentials and so forth. On the other hand, high gain bioelectric amplifiers have gain factors of more than ×1000 and usually used for very sensitive measurements such as brain waveform (EEG) measurements.

Bioelectric signal sources exhibit high source impedance thus the bioelectric amplifier used must have high input impedance. Therefore, the solution to both high gain and high input impedance problems is by using instrumentation amplifiers. It is one of the bioelectric amplifiers which use three operational amplifiers.

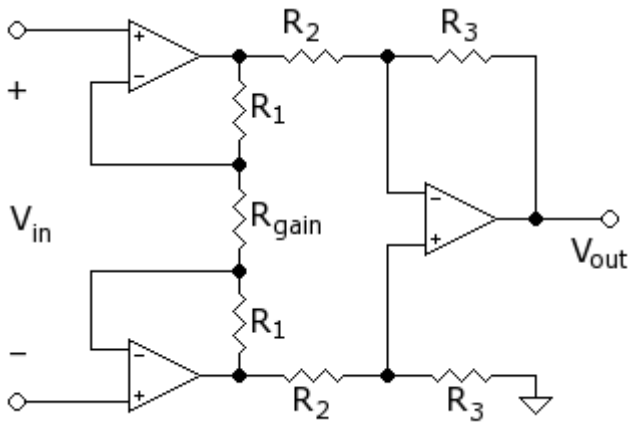

Figure 1.4 Instrumentation amplifier (Adapted from [7])

Instrumentation amplifier is a differential voltage gain device that amplifies the difference between the voltages existing at its two input terminals [8]. Instrumentation amplifiers are used in biomedical application for the purpose of amplifying small voltages such as bioelectric signals that may be riding on large common-mode voltages. The reasons instrumentation amplifiers are widely used in biomedical application are because of its ability to obtain high gain with low resistor values, extremely high input impedance, high common-mode rejection ratio, low output offset and low output ratio. The voltage gain is usually set with an external resistor. As shown in Figure 1.4, the first two amplifiers and the resistors are the buffers. Two input amplifier are connected in the non-inverting follower configuration that provide high input impedance and voltage gain. The gain can be controlled by the values of resistor R_1 and R_{gain} as indicated in equation (1.1).

$$A_v = \frac{2R_1}{R_{gain}} + 1 \tag{1.1}$$

For the second part on the right side of Figure 1.4, shows the third operational amplifier used as unity differential amplifier with high precision resistors that are equal in value. Therefore, the value of resistor $R_2 = R_3$. The properties of differential amplifiers are that they can reject equal noise on their inputs while amplifying unequal signal voltages on their inputs.

1.1.5 Microcontroller PIC16F877A

Microcontroller is a device that can be used as a complete computer on a single chip. Microcontroller is different than microprocessor because microprocessor is only a heart of a computer whereas microcontroller can work on its own. According to Harvard architecture, basic components are input/output (I/O) pin, program memory, data memory and arithmetic logic unit (ALU) as central control unit. On the other hand, according to Von Neumann architecture the basic

components of microcontroller only composed of I/O, ALU and memory where both data and program memory are stored in a same memory space [9] [10].

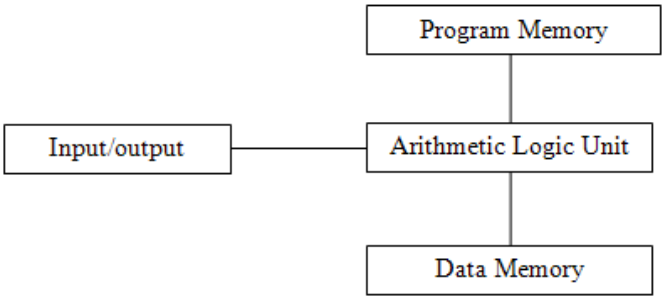

Figure 1.5 Microcontroller block diagram

PIC microcontrollers are popular with both industrial developers and hobbyist due to several advantages. The advantages are low cost, wide ability, large user base, an extensive collection of application notes, an availability of low cost or free development tools, ability to perform serial programming, and ability to re-programming with flash memory.

1.1.6 Bluetooth

Bluetooth technology is one of the wireless communication systems developed to replace the usage of cables in electronic devices. The aims for Bluetooth technology are short range, radio frequency (RF) based wireless communication between several devices. It was first developed by Ericson in 1994 and now the current developer is a special lobby of Special Interest Group (SIG) [11]. The first governing idea behind the Bluetooth technology is to replace cable and specify wide scale Integrated Circuit (IC) to be deployed on large scale on various type of equipment.

A complete Bluetooth system requires four elements. The first element is an RF portion for receiving and transmitting data. Second element is a module with a

baseband microprocessor. Third element that must have in Bluetooth module is memory and lastly, the fourth element is an interface to the host device such as mobile phone or laptop.

The advantages of this technology are low power consumption, low price, high level of integration and profile, simple Quality of Service (QoS) and error control, instantaneous networks, reliable and secure transmissions, and lastly this technology have global compatibility and compliant with global emission rule. This technology uses the unlicensed 2.4 GHz Industrial, Scientific and Medical (ISM) Band communication thus also compliant with airline regulation. So it is safe to be used on airlines [12] [13].

1.2 Problem Statement

In this modernization world nowadays, health becomes main concern of all party. Ever growing industry kept on increasing by day improving the technology. As widely known, heart attack is the leading cause of death for both men and woman worldwide. From Malaysian cause of death statistics, heart disease is the number one killer which is up to 12%. There are a lot of cases where patients not even realized that they actually have heart problems. Therefore, a mobile heart rate monitor will help patient identify the symptom of heart disease thus prevent sudden death caused by heart attack anywhere and anytime necessary. The other problem is that since Bluetooth architecture is compliant with global emission rule and available on unlicensed portion of the radio frequency 2.4 GHz ISM Band, therefore theoretically it can be used between medical devices. However, practically it is hard to achieve due to instability of Bluetooth transmission thus making a real time processing using Bluetooth is the least choice for wireless health telemonitoring.

1.3 Project Objectives

The main objective of this project is to design and develop a prototype system of hardware and software that can acquire and transmit heart beat wirelessly and display heart beat rate on laptop and mobile phone.

1.4 Scope of Work

In order to achieve the objective of the project, the scope of work includes;

i. Study on heart beat monitoring system and its working principal.
ii. Study on Bluetooth system and how it works.
iii. Designing a sensor circuit that can capture heart rate.
iv. Implementing amplifier circuit in the system so that the signal can be recorded easily.
v. Establish connections between microcontroller and Bluetooth system to program microcontroller to receive and transmit heart beat via UART
vi. Establish wireless connection between Bluetooth system and target device (Laptop and PDA) and display heart beat on the device's screen.

1.5 Thesis Outline

This thesis made up of five chapters. The first chapter presents the introduction to the project which includes research background, problem statement, objective of the project, and scope of work.

The second chapter presents about literature review on previous researches that have been done before. The research discussed includes wearable ECG system, methodology on how to obtain heart rate, heart rate monitoring using mobile phone, and other researches involving wireless technology.

In the third chapter is the methodology and circuit design used in this project. The details of the procedure for the project are also included in these chapters which are sensor, data acquisition, data processing, and wireless data transmission. The designed circuit also discussed in this chapter.

Fourth chapter is discussing on the results obtained in the project as well as the analysis of the result. Meanwhile, Chapter 5 concludes the reports and the findings. Also included in this chapter is the future research recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed on the projects that have been done previously such as wearable device, heartbeat monitoring system and blood pressure monitor. The previous work discussed in order to understand the project better.

2.2 Wearable Wireless ECG System

Nowadays, there are a lot of concepts like “wireless hospital”, “mobile healthcare”, or “wearable telemonitoring” emerge in medical technology industry. These concepts refer to the bio-signal acquisition devices that can make health monitoring easier even without staying in hospital.

Based on the research done previously, the most important feature for a wearable device is to have a small size and light weight. It also requires using only low power consumption. Furthermore, a wearable device must be able to interoperate with different mobile devices and communication networks in the environment. Above all, the most important feature of wearable device is to be able to do real time

processing. However, power consumption is a major limitation for mobile device because heavy long lasting battery is not convenient for wearable purpose.

In the research stated the description of the system built for the reconfigurable, wearable, wireless ECG system. The system consists of two parts; hardware system and monitoring application for the mobile phone or PDA.

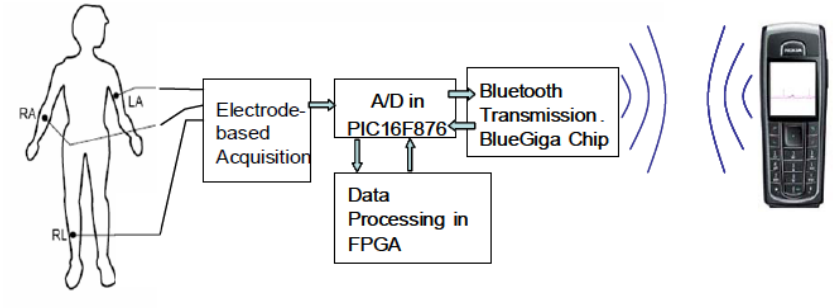

Figure 2.1 ECG system description (Adapted from [14])

The hardware system composed of three layers; acquisition layer, analog to processing layer and wireless transmission layer. Acquisition layer built using bioamplifier and a bandpass filter while transmission layer consist of Bluetooth module. The processing layer includes a microcontroller (PIC 16F876) and a FPGA (Xilinx Spartan3E-100). The functions of microcontroller are to capture and digitalize the ECG signal, establish the connection to the Bluetooth device and send the data [14].

2.3 Heartbeat Monitoring Alert via SMS

The proposed system discussed by [15] was about heartbeat monitoring via SMS. The hardware used involves sensor circuit, PIC circuit and MAX232 circuit. The software used to simulate the design, schematic capture and printed circuit board (PCB) design is PROTEUS 7.

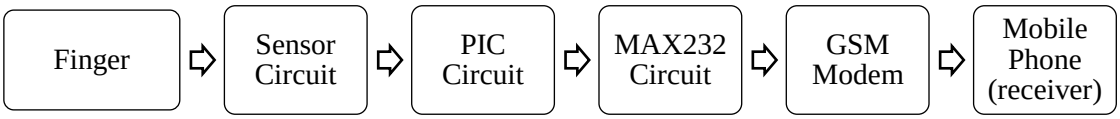

Figure 2.2 Heartbeat monitoring system block diagram

Heartbeat is sensed using high intensity LED (Light Emitting Diode) and LDR (Light Dependent Resistor). By illuminating the fingertip skin with the high intensity LED, any changes in blood volume in each pulse will be detected by LDR. With each heartbeat, a surge of blood from vascular system will expand capillaries in the finger thus changing the amount of light returning to the LDR. The PIC circuit then will process and analyze the signal and MAX-232 will be the interface between microcontroller and RS-232. The result obtained from the experiment is as Figure 2.3.

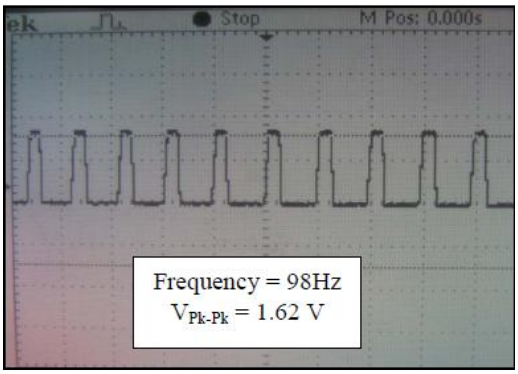

Figure 2.3 Result of heart rate obtained (Adapted from [15])

2.4 Mobile Phone Based Sphygmomanometer

The research is focusing on developing a high precision, non-invasive continuous blood pressure monitor using pulse arrival time. The software used in the research developed in the Eclipse integrated development environment with Java as the programming language. The environment for mobile phone used is the Doja 5.0 profile. Doja 5.0 is a Java runtime environment specification for DoCoMo's mobile phone based on the Java ME CLDC. The procedure to estimate blood pressure is firstly by obtaining ECG from the tip of finger from both hands and using index finger

of left or right hand to obtain pulse wave. Both ECG and pulse wave are sampled at 250 Hz filtered using notch filter and bandpass filter then transmitted to mobile phone. Figure 2.4 shows the sensor and the blood pressure measurement device while Figure 2.5 shows the result displayed on the mobile phone screen during blood pressure estimation. Table 2.1 shows the specification for communication between mobile phone sensors.

Figure 2.4 Blood measurement device (Adapted from [16])

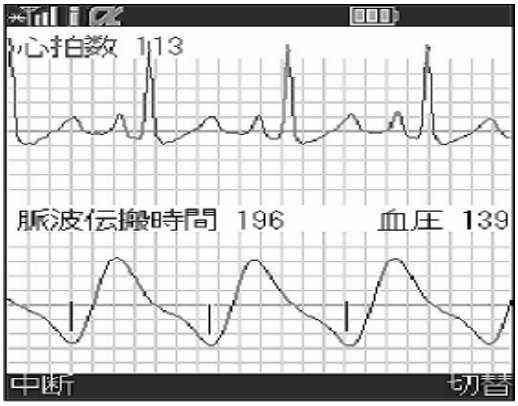

Figure 2.5 Display on mobile phone screen (Adapted from [16])

Table 2.1 Specification of communication between sensor and mobile phone

Band rate	38400 bps
Parity check	No
Stop bits	2 bits

In the investigation [16], blood pressure was measured on 13 subjects. Each subject's blood pressure was tested for three times to ensure data collected consistent. Compared to blood pressure obtained from the commercial blood pressure monitor, the systolic blood pressure obtained from mobile phone is slightly higher and diastolic blood pressure is slightly lower than average. However it is easier to obtain the result from mobile phone blood pressure than the commercial blood pressure monitor and the measurement result was not affected by gender or age.

2.5 Wireless Technology Related Research

J.H. Hong, *et al.* [17], discussed on the system which composed of transmitter, receiver and remote server. In the transmitter stage, the input was from measured ECG signal and fed to microcontroller before being sent to ZigBee transmitter, T_x. Then, in the receiver stage, the input transmitted from T_x will be received by ZigBee receiver, R_x and then transmitted to PDA. Data from the receiver also will be forwarded to remote server to be displayed on computer screen. The experiment was conducted using necklace type transmitter attached to a subject's sternum and the ECG signal was displayed on the screen of remote server receiver. Since the prototype developed able to operate even while the subject is moving, the system was suitable to be used by the old, the weak and the disabled people for consistent physical condition monitoring. The system designed also able to store the patient data continuously in the SD card and on the happening event, the data will be sent to remote server through the receiver.

Eric R. Grigorian, *et al.* [18], discussed in on a system developed which composed of MEMS sensor, microcontroller, Bluetooth and host computer. In their

research implementation, raw data was transmitted to base station for near real time processing. The hardware developed in the research focus in miniaturizes the design to produce compact size prototype which allow the ability to capture necessary biometrics for the analysis. On the host side, the data transmitted by Bluetooth appeared as bounded serial interface. The received raw data was de-packetized by removing start and stop bytes and the raw data was stripped out into an individual ECG for data analysis.

2.6 Conclusion

As for the conclusion of this chapter, mostly previous research on heartbeat monitoring system used same procedure which involves sensor layer, data acquisition layer and data processing layer. For wireless technology related researches, the methods used are very advanced and the prototype developed are considered applicable to healthcare systems. This information from previous research will help in completing this project.

CHAPTER 3

METHODOLOGY AND CIRCUIT DESIGN

3.1 Introduction

This chapter mainly concern about how data are generated and collected in the project as well as how they are analyzed to achieve the objective of the project. The detailed explanation on the procedure of the project is included in this chapter.

3.2 Methodology

The procedure used for the experiment can be divided into four parts; sensor, data acquisition, data processing, and wireless data transmission. The first part of the project was the sensor used to detect hart beat via PPG technique. Firstly, the sensor used was the reflective optical sensor with transistor output TCRT1000/TCRT1010.

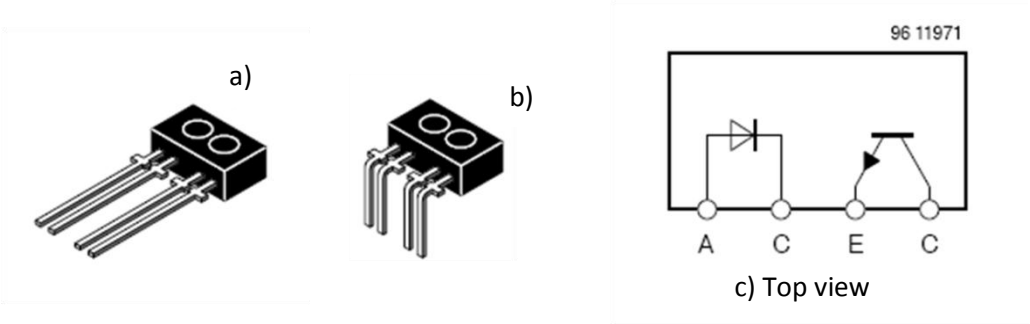

Figure 3.1 Optical sensor TCRT1000 (Adapted from [19])

The TCRT1000/1010 has a compact construction where light-emitting source and the detector were arranged in the same direction to sense the presence of any object by using the reflective IR-beam from the object. The features of this optical sensor are; compact construction in spacing of 0.1 with 7 mm length and 4 mm wide, no setting efforts, high signal outputs, low temperature coefficient, detector provided with optical filter and Current Transfer Ratio (CTR) of typical 2.5%. The sensing distance of the sensor is 1 mm. By referring to sensor block diagram in Figure 3.1c, a various values of resistor pair used to find the most suitable pair of resistor that can capture PPG signal from finger correctly. In this project, resistor 220 Ω and 100 kΩ was used where 220 Ω resistor was connected to C of the emitter and 5V power supply while resistor 100KΩ was connected to E and Ground. The A pin was connected to Ground and C pin of receiver was connected to 5V power supply.

The second part was the data acquisition circuit which used instrumentation amplifier INA114. Instrumentation amplifier was chosen due to its ability to obtain high gain, high input impedance, and high common mode rejection ratio.

The output of sensor was fed into pin 3 of instrumentation amplifier. As mention in introduction, using equation (1.1), gain can be calculated. Thus, Resistor 47 Ω was connected to R_G which is between pin 1 and 8 to obtain gain was calculated using equation (3.1) which is approximately 1000.

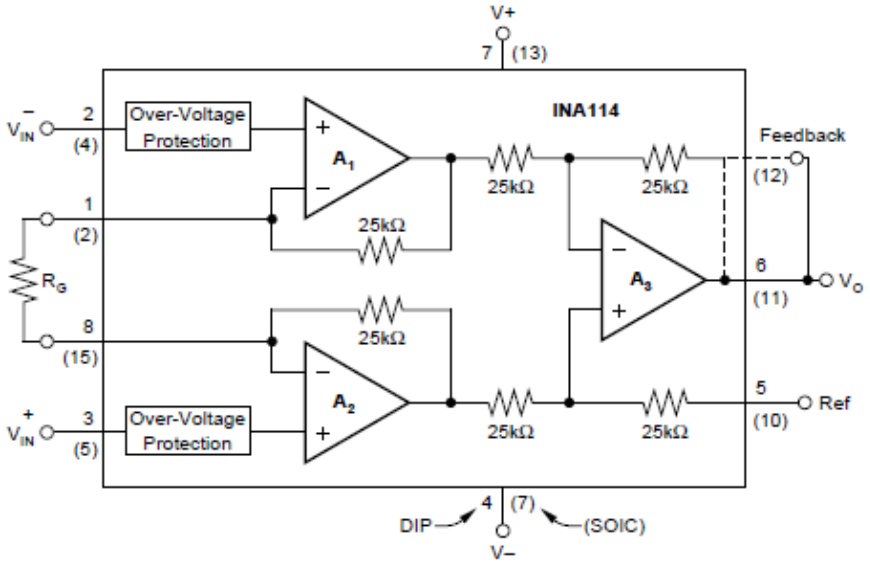

Figure 3.2 Instrumentation amplifier INA114 (Adapted from [20])

$$G = \frac{50\ k\Omega}{R_G} + 1 \qquad (3.1)$$

The third part of the system was the data processing. For this part, microcontroller PIC16F877A was used. Software MicroC PRO for PIC was used to program the microcontroller and PICKit2 was used as microcontroller programmer to burn the program into microcontroller. The amplified signal obtained from instrumentation amplifier was fed to the external interrupt of microcontroller PIC16F877A which is PORT A. PORT A was programmed to receive analog input and transmit the data to UART pin which was PORT C pin RC6 and RC7. Pin RC6 was microcontroller's transmitter pin thus it was connected to receiver pin of Bluetooth module. Meanwhile, pin RC7 was receiver pin of microcontroller thus it was connected to transmitter pin of Bluetooth module. The connection between microcontroller and Bluetooth is as shown in Figure 3.3.

The fourth part of this project was the wireless data transmission. Before the data can be transferred, Bluetooth connection was established first between the Bluetooth Module and the target device. Bluetooth Module came with a pair which was the Bluetooth Dongle. If the laptop used to receive the data already has Bluetooth device embedded, then Bluetooth Dongle was not needed.

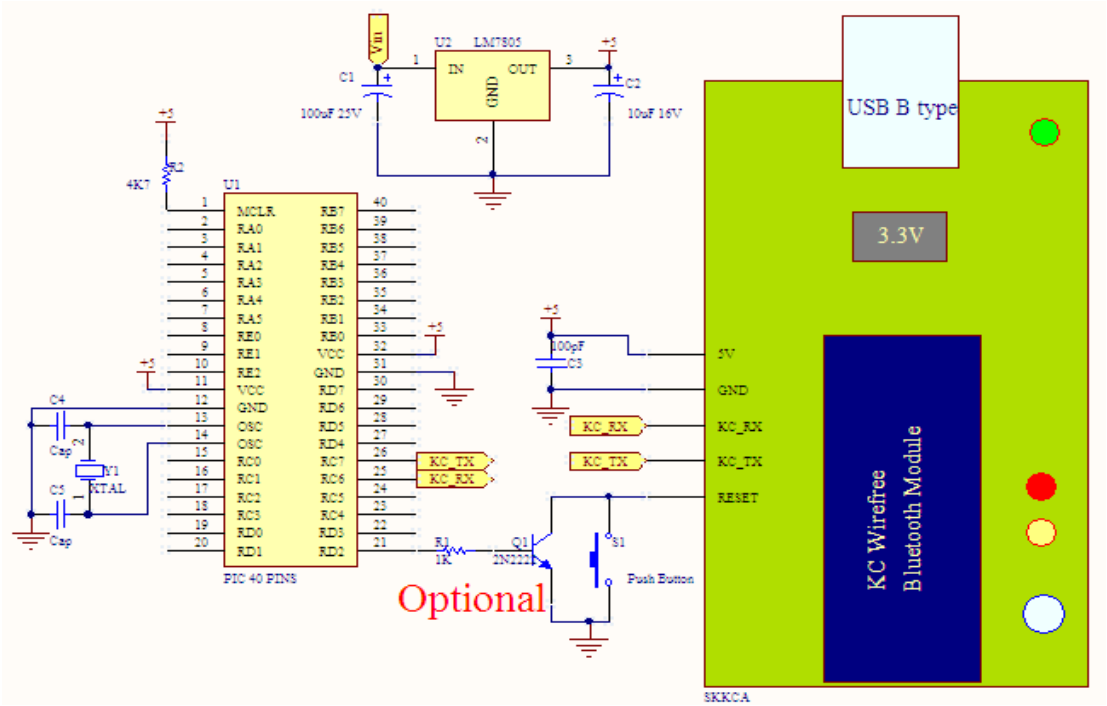

Figure 3.3 Block diagram of microcontroller and Bluetooth module (Adapted from [21])

The IVT BlueSoleil software was used to establish wireless connection between the Bluetooth Module and target devices which was laptop and PDA. To establish the connection, firstly all Bluetooth devices were turned on. When IVT BlueSoleil software detected the devices, all the devices appeared on the Bluetooth network range. Then, the devices were connected by right hand click on the device icon and connect to device option was clicked. COM PORT will be automatically assigned by computer. Different devices were assigned to different COM Port.

In the meantime, software Labview 8.6 was used to receive and display the output signal on the laptop. Firstly, VISA resource name was used to specify the input was from which COM Port. Then, it was connected to VISA serial to define serial communication properties especially the baud rate. For Bluetooth data transmission, baud rate used was 115200. Next, it was connected to VISA Read to read the data. Lastly, the data will be displayed using waveform chart. The Labview diagram of the receiver part is as illustrated in Figure 3.4.

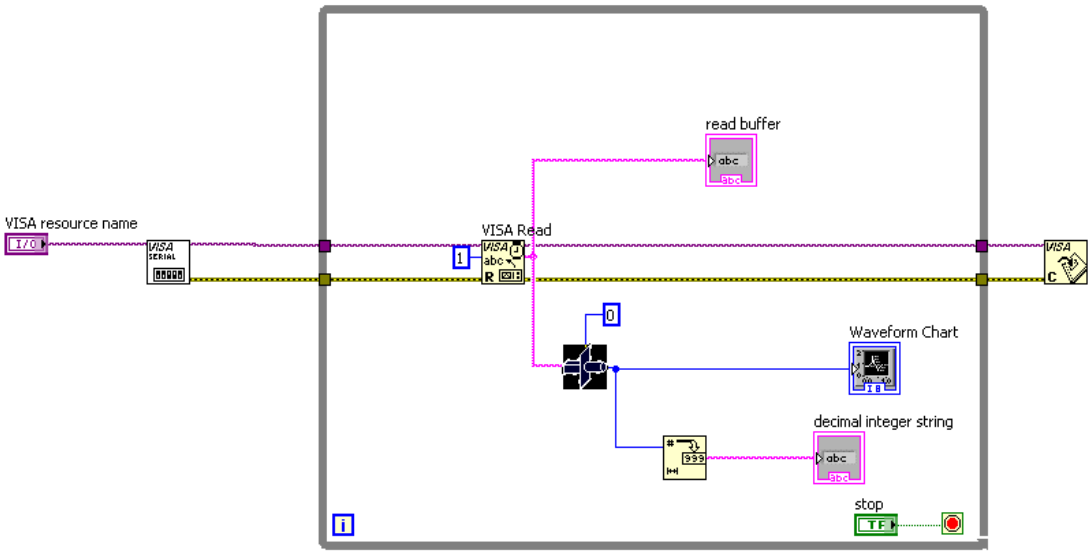

Figure 3.4 Labview receiver block diagram

3.3 Circuit Design

The instrumentation amplifier circuit was simulated in Multisim before it was implemented on protoboard. The components chosen was as stated in INA114 datasheet except that in Multisim, there is no 25 kΩ and 40 kΩ resistor so, resistor 24 kΩ and 39 kΩ was used instead. From equation (3.1), gain of instrumentation amplifier can be calculated.

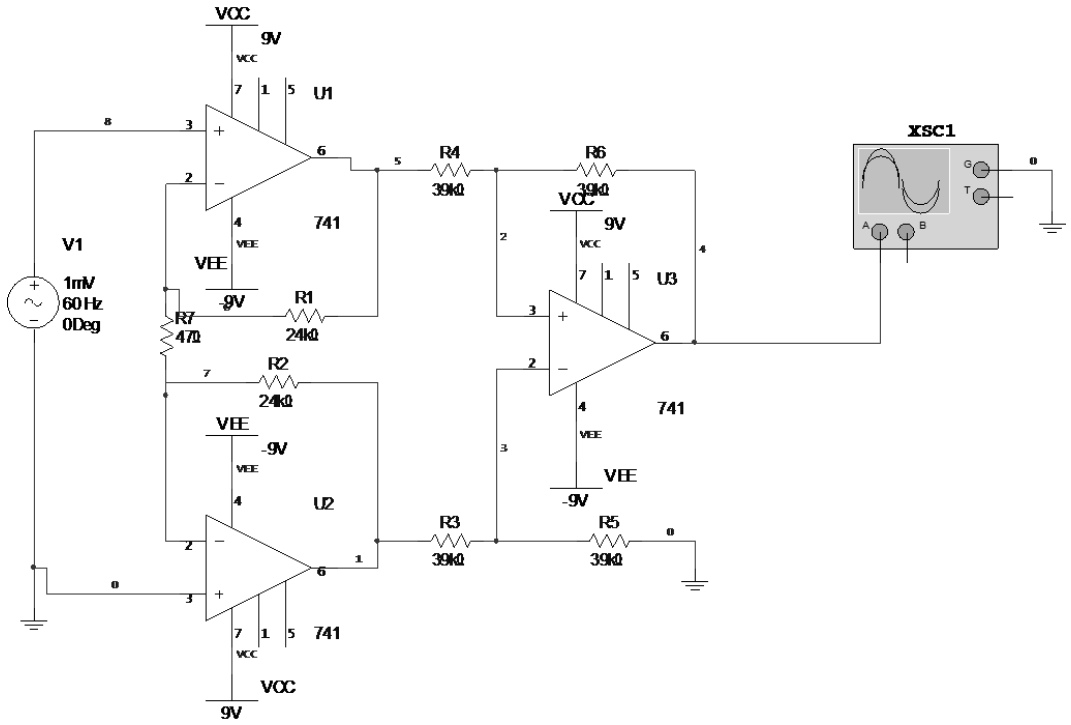

Figure 3.5 Simulation of instrumentation amplifier in Multisim

$$G = \frac{48\ \text{k}\Omega}{47} + 1 \qquad (3.1)$$

$$= 1022.27$$

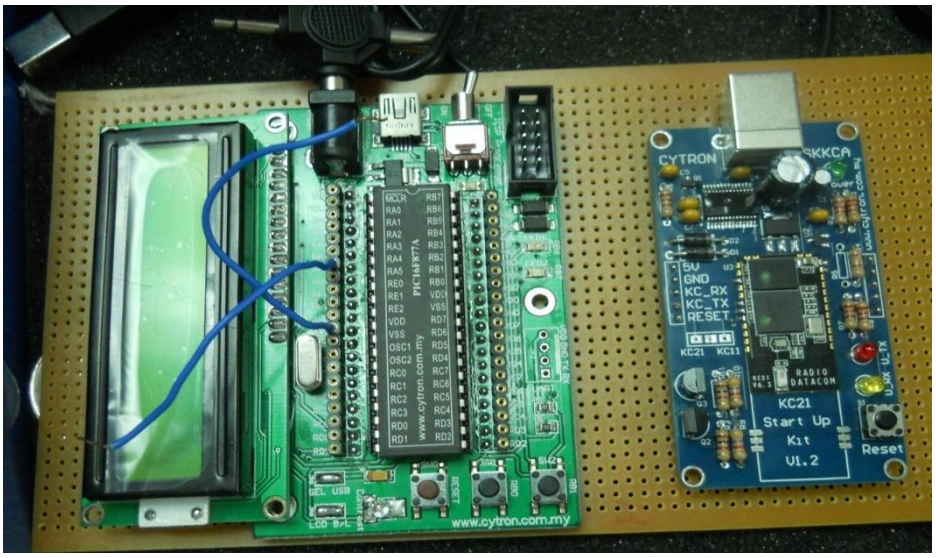

Figure 3.6 Microcontroller and Bluetooth module circuit

For microcontroller and Bluetooth module as shown in Figure 3.6, the circuit used was bought readily made from Cytron Technologies Sdn. Bhd. which is model SK40 and SKKCA. The connection between the microcontroller UART pin and Bluetooth pin was soldered afterwards. The yellow and red light emitting diode (LED) on the Bluetooth model will be used to indicate the data transmission. When data is transmitted, red LED blinked and when data is received yellow LED blinked.

3.4 Conclusion

This chapter discussed on the methodology used in the project. Generally, there are four stages in this project which are sensor circuit, data acquisition, data processing and wireless data transmission. Also included in this chapter are the circuits developed for this project.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter mainly discussed on the results obtained in this project. Every results was discussed regardless the success or failure of each result obtained. The reason behind every result is explained further in this chapter.

4.2 Results and Discussion

From the simulation done in Multisim, the output obtained was in Volts when given input of miliVolts which shows that instrumentation amplifer can amplify the gain until 1000. However, when the circuit was implemented on protoboard, the output obtained was not as simulated. Implemented circuit shows too much noise and the amplifier circuit did not manage to increase the gain. After a lot of trial done, the result showed that the amplifier circuit can only amplified the gain up to 20. There was also another problem occur which is the noise also amplified along the input signal.

Furthermore, the circuit designed also very unstable both sensor and amplifier because the output was not consistent. After a few consideration, the sensor part and

amplifier part was removed from the project due to time constraint. Instead, the input source was taken directly from ECG simulator and amplified using Biomedical Amplifier (BMA-400) as shown in Figure 4.1. The ECG simulator was set to give 80 BPM ECG pulse taken from right leg (RL) and right arm (RA). Left leg was set to be ground point in the ECG simulator. All three pin was connected to ISO-Z to give the polarity to the signal where RA is positive and RL is negative. Then ISO-Z device was connected to BMA-400 to amplify the ECG signal. In BMA-400, only channel 1 was used and it was set to give AC coupling, gain 1000 and band pass filter 3Hz for low frequency and 0.1Hz. The output of BMA-400 is as shown in Figure 4.2. Then, the output was fed to microcontroller pin RA5.

Figure 4.1 ECG simulator and BMA-400

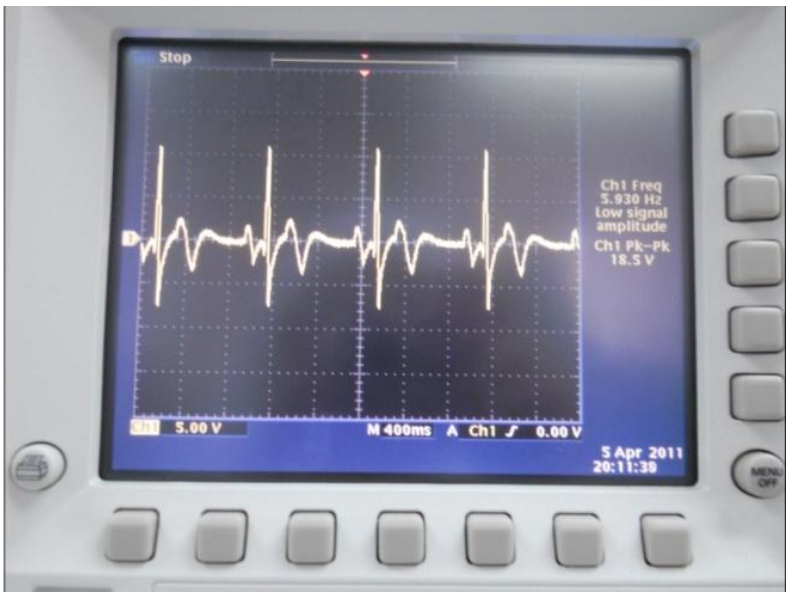

Figure 4.2 Output of BMA-400

In a meantime, wireless connection was established between the laptop, microcontroller and PDA was established. Since the range of Bluetooth network is about 10 meters, other Bluetooth device also appeared in the network. KcSerial icon in the Figure 4.3 indicates the microcontroller and the others are mobile phone and PDA.

Figure 4.3 Wireless connections

The COM port given by the laptop to microcontroller was COM 30 so in the Labview, serial communication was also set to be COM 30 so that the data can be transmitted and displayed on the laptop screen as displayed in Figure 4.4.

From the output obtained in the Labview, we can see some of the similarities between the output of BMA-400 and as shown in the Labview especially for P peak and R peak of the signal. However, the signal obtained after wireless transmission was not as smooth as the output given. This shows that for real time processing, the

data transmission using Bluetooth will not yield accurate data. Even if it does, the data transmitted must be filtered and processed before it can be used for medical diagnosis. This finding further proved that real time data transmission is hard to achieve due to unstability of Bluetooth transmission.

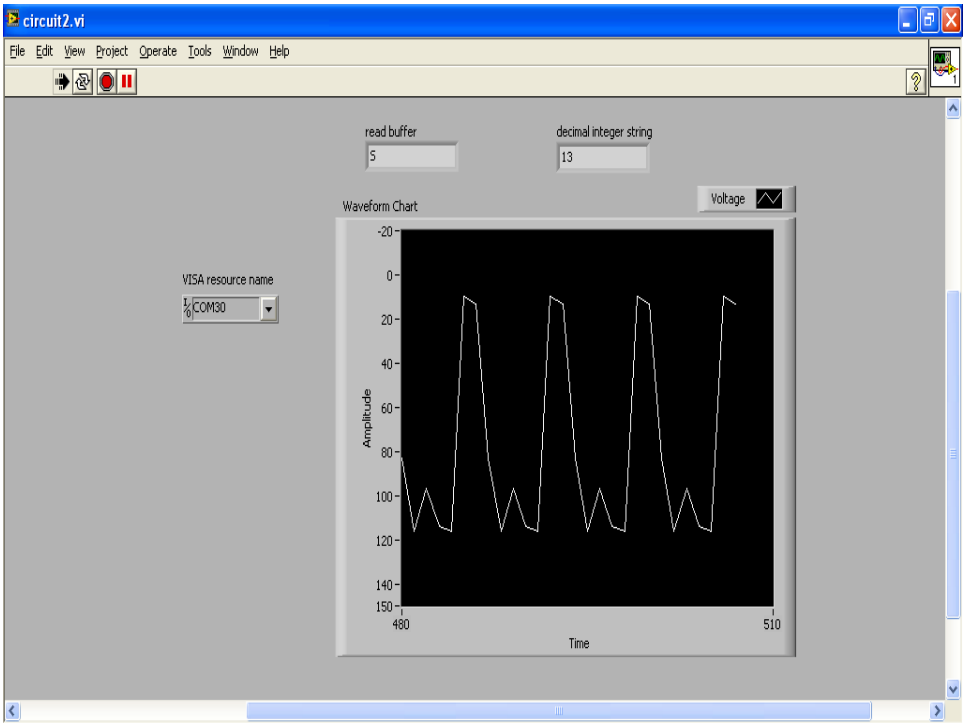

Figure 4.4 Output from Labview 8.6

Supposedly, after the data was transmitted to laptop it must also be transmitted to PDA for diagnosis. However, Labview 8.6 software was unable to detect the device because the software used was a trial version. Thus it does not have any PDA module. Other version of Labview was used which is Labview 8.0 but since the version used is more previous than the 8.6 version, the data were unable to be retrieved from input. Although Labview version 8.0 have PDA module installed, the software still unable to detect the device. Thus, no data were able to be displayed on the PDA.

4.3 Conclusion

This chapter has discussed all the results obtained in the project. Since the first and second part of the project failed to produce usable output, both stages were removed and replaced by ECG simulator input. The input used was amplified using Biomedical Amplifier BMA-400. Bluetooth data transmission of the input was successfully displayed on the laptop but the output obtained differs than the input given due to transmission problem. Lastly, the output was unable to be displayed on PDA due to software related problem.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

To conclude this report, generally there are four stages in this project which are sensor, data acquisition, and data processing and wireless data transmission to laptop and PDA. However, due to instability of sensor and data acquisition hardware, both first and second stage was eliminated from the project. For testing purpose, input was taken from ECG simulator and amplified by Biomedical Amplifier BMA-400. The input was fed into microcontroller which has been programmed to transmit the data wirelessly using Bluetooth module. Wireless data transmission was successfully retrieved by laptop and viewed on the screen. However, the data obtained was not as smooth as the input given due to transmission problem. Wireless data transmission to PDA was not successfully achieved due to software related problem.

Therefore, this project succeed to fulfill the main objective of this project which is to design and develop a prototype system of hardware and software that can acquire and transmit heart beat wirelessly and display heart beat rate on laptop and mobile phone.

However the output of the prototype system was not as accurate as the input given thus making it hard to be used for medical diagnosis. This project has proven the theory which Bluetooth wireless data transmission can be used between medical devices however, it is hard to achieve due to its unstability of Bluetooth transmission

thus making a real time processing using Bluetooth is the least choice for wireless health telemonitoring.

5.2 Future Development

For future research, Bluetooth technology was not recommended to be used as wireless data transmission between medical devices especially for real time data processing because real time data processing requires accurate data transmission. Even if it can be used, there must be a lot of data processing and filtering before the data can be used for medical diagnosis. It is also recommended to use ZigBee or GSM Module for wireless data transmission and SMS alert.

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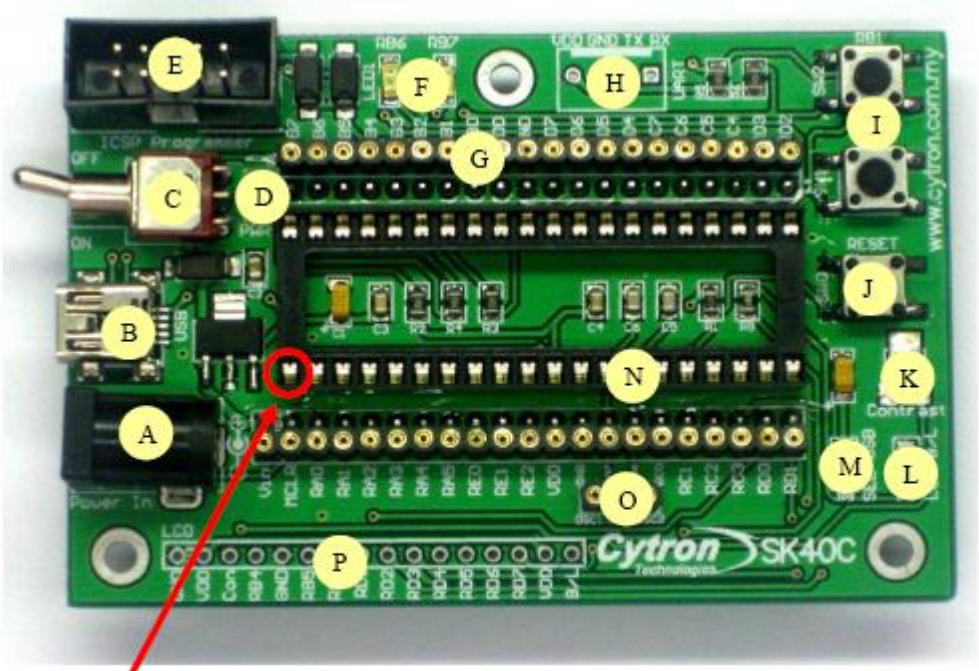
APPENDIX A

COMPONENTS DATASHEET



a) Top View

Label	Function	Label	Function
A	DC power adaptor socket	**I**	Programmable Push Button
B	USB Connector	**J**	Reset button
C	Toggle Switch for power supply	**K**	LCD contrast
D	Power indicator LED	**L**	JP8 for LCD Backlight
E	Connector for UIC00A Programmer	**M**	JP9 for USB
F	LED Indicator	**N**	40 pin IC socket for PIC MCU
G	Header pin and turn pin	**O**	Turn pin for crystal
H	UART Connector	**P**	LCD Display

Figure A.1 Microcontroller board layout

A – DC power adaptor socket for user to plug in DC adaptor. The input voltage should be ranged from 7 to 15V.

B – USB connector for communication between devices and a host controller (usually personal computers). This function is only valid for certain model of PIC microcontroller. Please refer to USB interface section. The power LED will light ON when the USB cable is connected.

C – Toggle switch to On/Off the power supply from DC adaptor.

D – Power indicator LED for on board. It will light ON as long as the input power is correctly connected.

E – 2x5 box header for UIC00A, USB ICSP PIC Programmer.

F – 2 LEDs (connected to RB6 and RB7) as active High output for PIC MCU. These LEDs are controllable from PIC MCU.

G – Consist of several line of header pin and turn pin. Header pin provide connector for user to solder SK40C to prototype board and use the I/O of PIC MCU. It is fully compatible between SK40B. Turn pin offer simple way to check voltage with multi-meter probe. 40 pins of PIC MCU except OSC (connected to crystal) are extended out to these pin. There is an extra pin on top of MCLR which is labeled as Vin, is connected to the input power.

H – Reserved for UART communication. Tx and Rx pin of SK40C are connect to RC6 and RC7 respectively. Ensure PIC use have the correct UART pin (RC6 and RC7).

I – 2 x Push button connected to RB0 and RB1 of PIC MCU. This is extra input button for user. It can be programmed as input switch.

J – Push button with the function of Reset for PIC MCU.

K – 5K of trimmer to set LCD contrast.

L – JP8 is provided for LCD Backlight. LCD Display will have backlight if this pin is shorted.

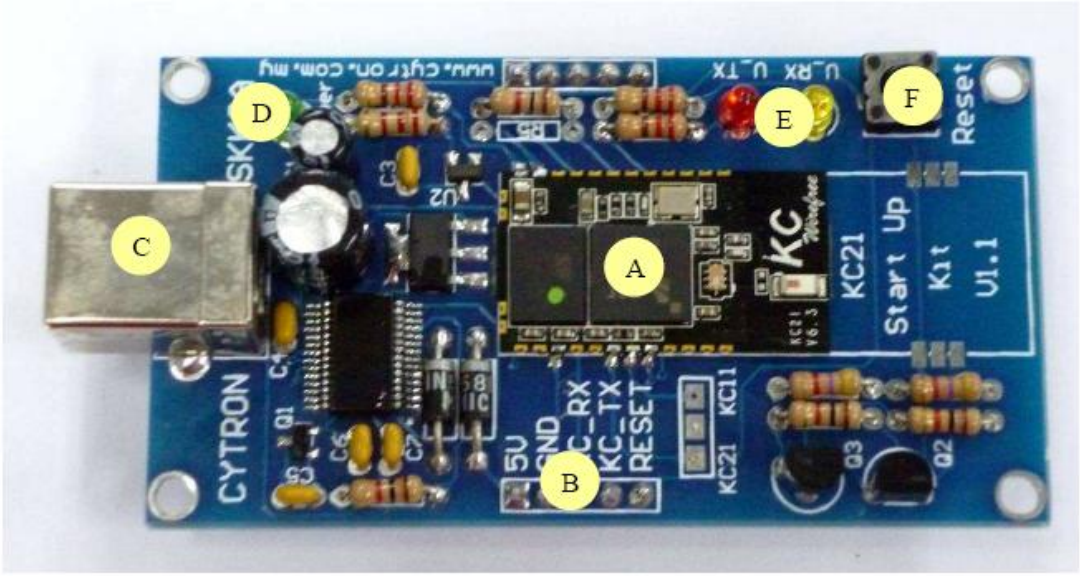
M – JP9 is provided for USB. Connect this pin if users use USB port

N – 40 pin IC socket for user to plug in any 40 pin PIC MCU (8 bit). It can either be 16F or 18F PIC. Of course the IC package should be PDIP. **Please ensure the first pin is at the top side.** Inside IC socket, there some electronics components, it include a 20MHz Crystal.

O – Turn pin is provided for crystal. 20M Hz is default crystal provided in SK40C. However, the 20M Hz crystal can be removed and replace with other crystal. Just remove the crystal and put other crystal on turn pin without soldering.

P – Reserved for 2 x 16 LCD Display. User may solder 2x16 LCD display at this space if want to use it.

Figure A.2 Further explanation on microcontroller board layout



Label	Function
A	KC Wirefree Bluetooth module
B	5 ways header pin for external power and interface to microcontroller
C	USB B type socket
D	On board 3.3V power indicator LED. It is green color
E	Two LED indicator for USB's transmitter and receiver status
F	On board reset button for KC Wirefree Bluetooth module

A – Either KC21 or KC11 will be mounted. This is KC Wirefree Bluetooth module

B – 5 ways header pin for external power supply and interface to microcontroller. If this kit is connected to microcontroller board, it should be powered with 5V. Please refer to hardware installation for detail connection.

C – USB B type socket. If connection to PC or laptop is required, please connect one end of USB cable (B type) to this socket, while the other end to PC or laptop.

D – 3.3V power indicator. This small green LED indicates the status of 3.3V output from on board regulator. It should be ON if either external 5V power or USB connection is connected to SKKCA.

E – These are a pair of small LED, red and yellow in color. These LEDs are connected to on board USB to UART converter. It indicates the receiver and transmitter activity. It will only work if SKKCA is connected to PC or laptop through USB cable. Red LED indicate USB's transmitter send data, while yellow LED indicate USB's receiver receive data.

F – Reset button for KC Wirefree Bluetooth module. Pressing this button will reset on board KC Wirefree Bluetooth module.

Figure A.3 Bluetooth module board layout

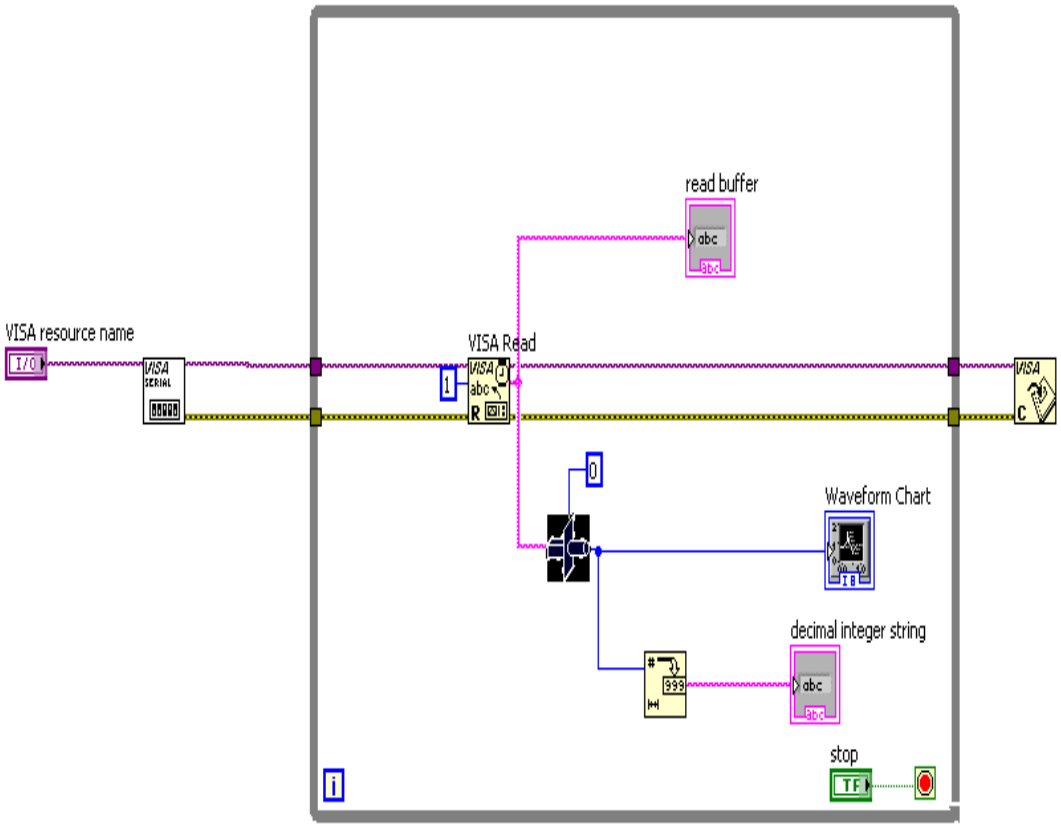
APPENDIX B

PROGRAMMING SOURCE CODE

```
char uart_rd;
void main() {


  ADCON1 |= 0x0F;               // Configure AN pins as digital
  CMCON  |= 7;                  // Disable comparators

  UART1_Init(115200);           // Initialize UART module at 115200 bps
  Delay_ms(100);                // Wait for UART module to stabilize

  UART1_Write_Text("Start");
  UART1_Write(10);              // Line feed
  UART1_Write(13);              // Carriage return

  while (1) {                   // Endless loop
   if (UART1_Data_Ready()) {    // If data is received,

     uart_rd = UART1_Read();    //   read the received data,
     UART1_Write(uart_rd);      //   and send data via UART
    }
  }
}
```

APPENDIX C

LABVIEW RECEIVER CIRCUIT DESIGN



LABEL	FUNCTION
VISA Resource Name	Select input port wireless transmission
VISA Serial	Specify serial communication properties such as Baud rate For Bluetooth, Baud rate = 115200 bps
VISA Read	Read data received from transmitter
Read buffer	Buffer to wait for next data received
Waveform Chart	Display the data received in amplitude versus time
Decimal integer string	Buffer to wait for data to be displayed in waveform cart
Stop	To stop receiving the data

Figure C.1 Labview block diagram and functions